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INTEGRAL FLANGE DESIGN PROGRAM

By

John F. Wilson

March 1974



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**NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
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| 16. Abstract This paper describes an automated "interactive" flange design program utilizing an electronic desk top calculator. The design equations are from the ASME Boiler and Pressure Vessel Code, Section VIII. The program calculates the operating and seating stresses for circular flanges of the integral or optional type subjected to internal pressure. The required input information is documented. The program provides an automated procedure for computing stresses in selected flange geometries for comparison to the allowable code values. | | | |
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INTEGRAL FLANGE DESIGN PROGRAM

By

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HAMPTON, VIRGINIA

SUMMARY

The flange design methods in this program are applicable to circular flanges under internal pressure. The gaskets must be entirely within the bolt circle and the outer rims of the flanges must not touch under the applied loading. This paper presents an automated design solution to integral and optional type flanges using the methods in the 1971 edition of the ASME Boiler and Pressure Vessel Code, Section VIII, Division I, Appendix II, pages 210-221 (reference 1).

The program calculates the stresses associated with a given geometry and prints the required flange thickness to assure that the working stresses are within the allowed code values. It is the responsibility of the designer to be sure the geometry conforms to code requirements such as maximum hub taper, maximum bolt spacing, number of bolts and size of bolts, as well as allowable materials and material properties.

The program was written for use with the Hewlett-Packard Model 9810A Calculator and programmed using their operating manuals (reference 2).

EQUIPMENT NEEDED

- PRINTER
 9860A MARKED CARD READER
 9881A TYPEWRITER
 9882A PLOTTER

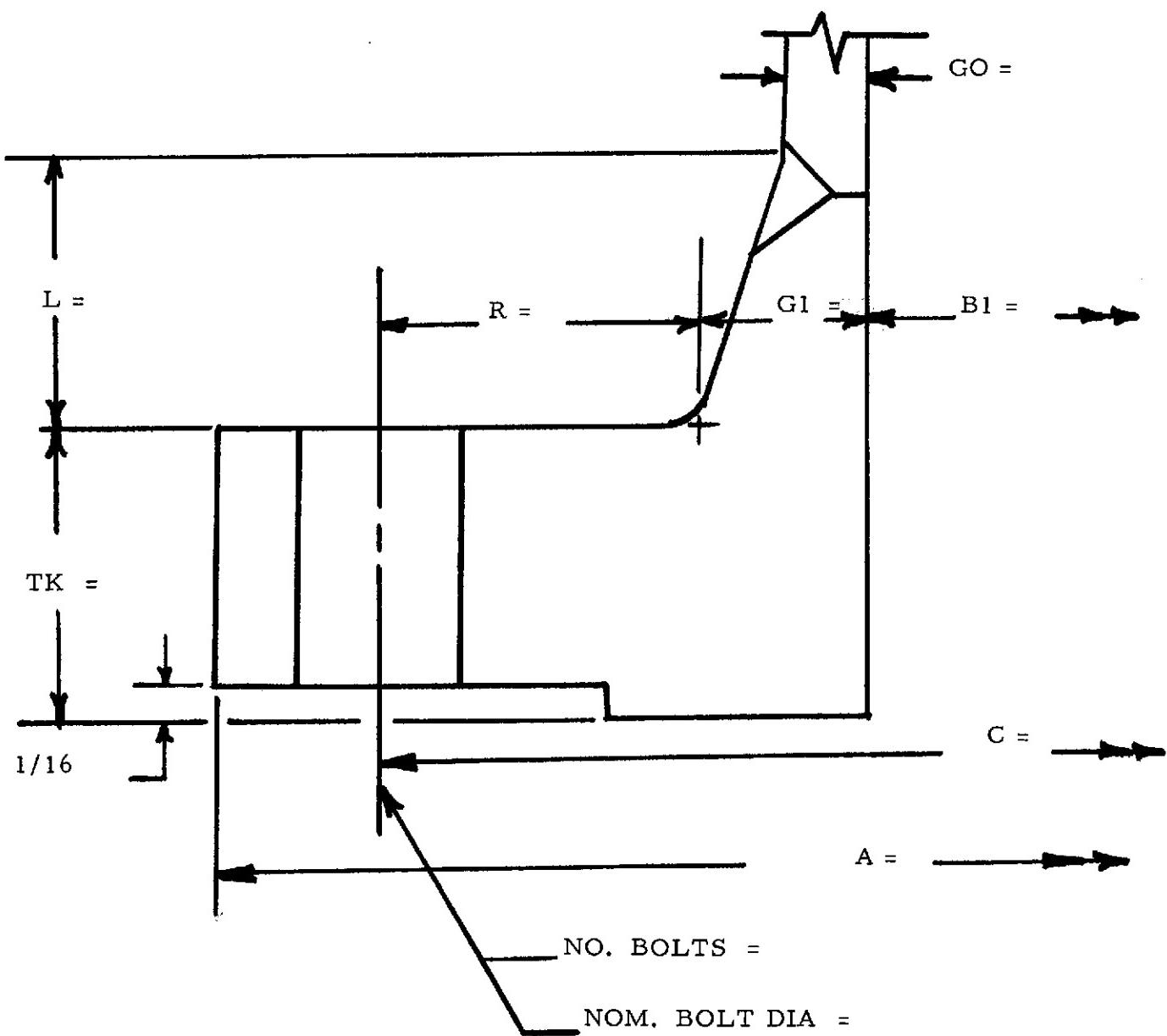
| TOTAL REGISTERS | TOTAL PROGRAM STEPS | ROM'S |
|--|--|------------------------|
| <input checked="" type="checkbox"/> 51 | <input type="checkbox"/> 500 | 1 <u>Mathematics</u> |
| <input type="checkbox"/> 111 | <input type="checkbox"/> 1012 | 2 <u>Printer ALPHA</u> |
| | <input checked="" type="checkbox"/> 2036 | 3 _____ |

| STEP | USER INSTRUCTION | DISPLAY |
|------|---|---------|
| | Before using calculator: | |
| 1 | Determine a flange material (ASME Code) | |
| 2 | Determine a bolting material (ASME Code) | |
| 3 | Determine a flange Geometry (See Page 3) | |
| 4 | Determine Gasket Details (See Page 4 & 5) | |
| 5 | Determine Flange Facing Details (See page 6) | |
| 5a | Determine Design Pressure and Temperature | |

Now go to Calculator

- 6 Press: End
 7 Press: Load (Load Program)
 8 Press: Clear
 9 Press: End
 10 Press: Continue
 Using symbols and definitions (pages 7, 8, 9, 10) Input information to calculator as requested. When no error messages appear (See sample program output pages 12 & 13) design stress and flange thickness requirements have been satisfied. Designer may still select a flange thickness to iterate to closest acceptable thickness giving no error messages.

INTEGRAL FLANGE GEOMETRY



PRESSURE VESSEL CONSTRUCTION

FACINGS AND GASKETS

(Reference 3)

Suggestions as to the choice of facing and type of gasket to suit particular applications and service conditions are not covered in this Manual. Pressure, temperature, thermal shock, cyclic operation and the fluid handled are all factors to be considered. All sections of the American National Standard Code for Pressure Piping (ANSI B31) contain rules for flange facings and gaskets and these serve as valuable guides. Reference should also be made to American National Standard ANSI B16.5, covering "Steel Pipe Flanges and Flanged Fittings". This Standard provides facing dimensions for flanges in the 150 lb. through 2500 lb. classes in sizes through 24" and also refers to gasketing. Similar data for sizes 12" through 36" in classes 150, 300, 400, 600 and 900 lb. is given in the Manufacturers Standardization Society's Standard Practice MSS SP-44.

Flange facings may be classified as (1) those sealed by pressure on the gasket from bolt loading and (2) those sealed by self equalizing gaskets that function by internal fluid pressure. The first group includes raised and flat faces where the gasket is restrained only by loading. The gasket is confined in a recess when Male and Female, Tongue and Groove, and Ring Joint are used. Such facings provide greater unit pressure and offer more protection against blow-out.

Raised Face Gaskets for raised faces may extend to the inner edge of the bolt holes for centering control. The O.D. of the raised face may extend to the same point at the option of the designer, but because of machining tolerances, it is advisable to keep it smaller. The gasket O.D. for design purposes is equal to the O.D. of the raised face. Spiral Wound gaskets work best when the O.D. of the gasket is slightly smaller than the O.D. of the raised face. They should be provided with a compression and centering guide to insure proper location.

The gasket need not cover the entire width of the raised face as this requires additional bolt load. For certain corrosive services, locating the gasket 1/8" from the flange I.D. helps protect the flange face.

Male and Female In this type of joint the O.D. of the gasket is the same as that of the male face. The female facing is made larger than the male face to receive the gasket and provide interlock.

Tongue and Groove For this type of facing the width of the gasket is made equal to the width of the tongue, which, for clearance purposes, is narrower than the groove. The joint proportions are shown in Figure 1c, page 6. The detail shows a "nubbin". This is used to reduce the effective seating width of the gasket.

Ring Joint Suggested minimum edge distances are shown in Figure 1g. For reasons of economy and sound design, it is recommended that grooves for ring type joints conform with ANSI or MSS Standards whenever possible. ANSI B16.5 and B16.20 cover sizes through 24" and MSS SP-44 covers sizes 26" through 36". In larger sizes the configuration and proportions of the groove should follow those established by these Standards.

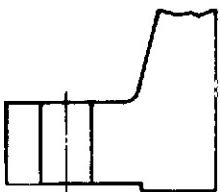
It should be noted that neither Standard refers to rounded-bottom grooves. Unless otherwise specified, flat bottom grooves should be provided. While either oval or octagonal rings may be used with flat bottom grooves, the octagonal type is preferred.

Self Equalizing Types The self equalizing type of gasket, such as O-Ring, Delta-Ring and Lens-Type, are useful for high pressure applications. These gaskets and the special flange facings required for them are shown in Figure 1e, page 6. Joints of this kind have the distinct advantage of not requiring mechanical loading for gasket seating. Since the gasket reaction can be considered negligible, the total bolting is only that necessary to retain the hydrostatic end force.

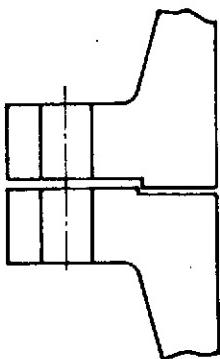
A great deal of research and experimental work has been done in connection with joints of this type. No attempt is made here to cover the subject in detail. Where metal O-Rings are required, they should have a plating of soft metal (copper, for example) and be used with 16 AA maximum surface finishes.

*TYPICAL FLANGE FACINGS—Fig. 1
(Reference 3)

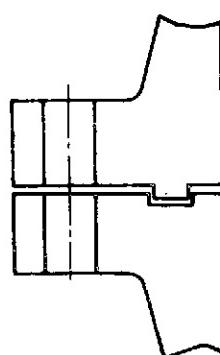
a.
Raised Face



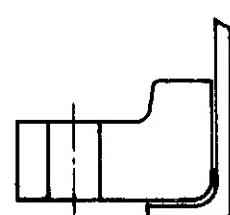
b.
Male And Female



c.
Tongue And Groove

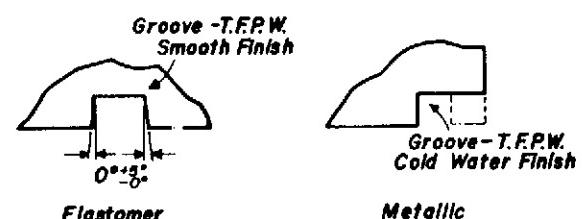
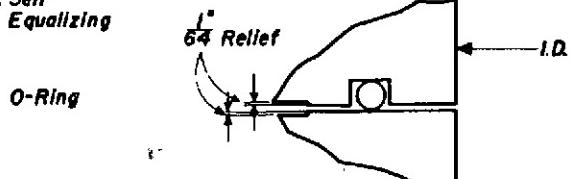


d.
Lap Joint

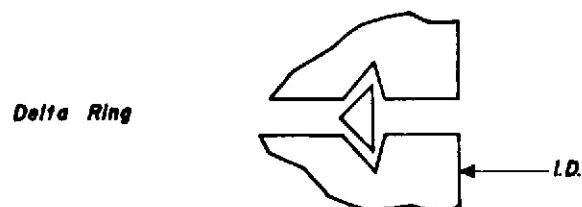


FACING DETAILS

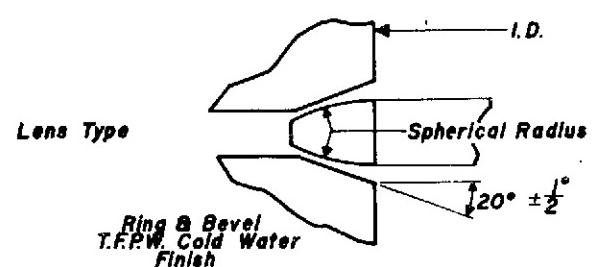
e. Self Equalizing



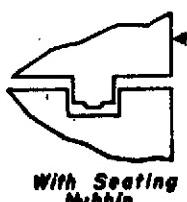
Delta Ring



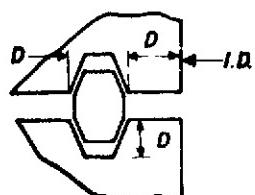
Lens Type



f.
Tongue And Groove



g.
Ring Joint



*From Taylor Forge "Modern Flange Design", Bulletin 741

INTEGRAL FLANGE DESIGN

NOTATION SYMBOLS AND DEFINITIONS

ALL SYMBOLS ARE SHOWN IN THE ORDER THEY APPEAR IN THE PROGRAM

The definitions are those given in Appendix II of the 1971 ASME Boiler and Pressure Vessel Code, Section VIII, Division I.

B = Effective gasket or joint contact-surface seating width, inches.

$$B=b_0, \text{ when } b_0 \leq \frac{1}{4} \text{ inch}$$

$$B=\frac{\sqrt{b_0}}{2}, \text{ when } b_0 > \frac{1}{4} \text{ inch}$$

b_0 =basic gasket seating width, inches, see Table UA-49.2, page 14.

Y = Gasket or joint-contact-surface seating load, pounds per square inch, Table UA-49.1, page 15.

M = Gasket factor, Table UA-49.1 page 15.

G = Diameter at location of gasket load reaction.

when $b_0 \leq 1/4$ inches, G = mean diameter of gasket contact face, inches.

when $b_0 > 1/4$ inches, G = outside diameter of gasket contact face less $2D$, inches.

$WM2$ = Minimum required bolt load for gasket seating, pounds, $\equiv B\pi GY$

P = Design pressure, pounds per square inch.

HP = Total-joint-contact surface compression load, pounds, $\equiv 2\pi BGMP$

H = Total hydrostatic end force, pounds, $\equiv \frac{\pi}{4} G^2 P$.

$WM1$ = Required bolt load for operating conditions, pounds, $\equiv HP+H$

SA = Allowable bolt stress at atmospheric temperature, pounds per square inch. Select from ASME Code for required material.

SB = Allowable bolt stress at design temperature, pounds per square inch. Select from ASME Code for required materials.

AM = Total required cross-sectional area of bolts taken as the greater of $AM1$ or $AM2$, square inches.

| | | | |
|--------|--|------|---|
| AM1 | = Total cross-sectional area of bolts at root of thread or section of least diameter under stress required for the operating conditions, square inches, $\equiv \frac{(W1)}{(SB)}$ | HG | = Gasket Load (difference between flange design bolt load and total hydrostatic end force), pounds, $= W-H \equiv H_p$ |
| AM2 | = Total cross-sectional area of bolts at root of thread or section of least diameter under stress required for gasket seating, square inches, $\equiv \frac{(W2)}{(SA)}$ | HT | = Difference between total hydrostatic end force and the hydrostatic end force on area inside of flange, pounds, $\equiv H-H_D$ |
| AB | = Actual total cross-sectional area of bolts at root of thread or section of least diameter under stress, square inches. (Must be equal to or greater than AM). | HGG | = Possible gasket seating load due to bolting, pounds, see UA-49, paragraph (b) item (3), sub item (d), formula (4), $\equiv W$ |
| W | = Flange design bolt load for the operating conditions or gasket seating, as may apply, pounds, $\equiv .5(AM+AB)(SA)$ | R | = Radial distance from bolt circle to point of intersection of hub and back of flange, inches, (integral and hubbed flanges). |
| N(Min) | = Minimum width, in inches, required for the basic gasket seating width, based upon the possible contact width of the gasket. Has no meaning if Y=0, $\equiv (AB)(SA)/2Y\pi G$. | G1 | = Thickness of hub at back of flange, inches. |
| B1 | = Inside diameter of flange, inches. When B1 is less than 20 G1, it will be optional for the designer to substitute BB for B1 in the formula for longitudinal hub stress, SH. | C | = Bolt-circle diameter, inches. |
| BB | = B1+GO for integral-type flanges when FC is equal to or greater than 1. | HD1 | = Radial distance from the bolt circle to the circle on which HD acts, inches, $= R+.5(G1)$. |
| HD | Hydrostatic end force on area inside of flange, pounds, $\equiv \frac{\pi}{4} B^2 P$. | HG1 | = Radial distance from gasket load reaction to the bolt circle, inches, $\equiv \frac{C-G}{2}$. |
| | | HT1 | = Radial distance from the bolt circle on which HT acts, inches $\equiv .5(R+(G1)+HG)$ |
| | | HG1G | = Radial distance from gasket load reaction to the bolt circle, inches, $\equiv \frac{C-G}{2}$ |
| | | MD | = Component of moment due to HD, inch-pounds, $\equiv (HD)(HD1)$ |
| | | MG | = Component of moment due to HG, inch-pounds, $\equiv (HG)(HG1)$ |
| | | MT | = Component of moment due to HT, inch-pounds, $\equiv (HT)(HT1)$ |

MO = Total moment acting upon the flange for the operating conditions, inch-pounds,
 $\equiv MD + MG + MT$
 MOG = Total moment acting upon the flange for the gasket seating, inch-pounds, $\equiv (HGG) (HG1)$
 A = Outside diameter of flange or, where slotted holes extend to the outside of the flange, the diameter to the bottom of the slots, inches.
 K = Ratio of outside diameter of flange to inside diameter of flange, $\equiv \frac{A}{(BT)}$.
 T = Factor involving K, shape constant.
 U = Factor involving K, shape constant.
 Z = Factor involving K, shape constant
 YS = Factor involving K, shape constant
 GO = Thickness of hub at small end, inches
 G1/GO = Shape constant.
 HO = Factor $\equiv \sqrt{(B1)(GO)}$, inches.
 L = Hub length, inches
 H/HO = Shape Constant.
 F = Factor for integral-type flanges, figure UA-51.2, page 16.
 V = Factor for integral-type flanges, figure UA-51.3, page 16
 FC = Hub stress-correction factor (for integral-type flanges). For values below limit of chart use $FC = 1$. Figure UA-51.6, page 17.

E = Factor for integral-type flanges, $\equiv \frac{F}{(HO)}$
 D = Factor for integral-type flanges, $\equiv \frac{U}{V} (HO)(GO)^2$.
 TK = Flange thickness, inches, assumed value.
 ALF = Stress formula factor, $\equiv (TK)(E)+1$.
 BTA = Stress formula factor, $\equiv (4/3)(TK)E+1$.
 GMA = Stress formula factor, $\equiv ALF (T)$.
 DEL = Stress formula factor, $\equiv (TK)^3/D$.
 LMA = Stress formula factor, $\equiv GMA+DEL$.
 MM = $\frac{MO}{BT}$
 MMG = $\frac{MOG}{BT}$
 BS = Bolt spacing, inches
 SH = Calculated longitudinal stress in hub, pounds per square inch, (operating conditions), $\equiv (FC)(MM)/(LMA)(G1)^2$.
 SR = Calculated radial stress in flange, pounds per square inch, (operating conditions), $\equiv (BTA)(MM)/(LMA)(TK)^2$.
 ST = Calculated tangential stress in flange, pounds per square inch, (operating conditions), $\equiv [(MM)(Y)/(TK)^2] - Z(SR)$
 SC = Combined stress greater of .5(SH+SR) or .5(SH+ST)

SF0 = Allowable design stress for material of flange, nozzle neck vessel or pipe wall, at design temperature (operating conditions), pounds per square inch. Select from ASME Code for required material.

SHG = Calculated longitudinal stress in hub, pounds per square inch, (gasket seating condition), $\equiv (FC)(MMG)/(LMA)(G1)^2$.

SRG = Calculated radial stress in flange, pounds per square inch, (gasket seating conditions), $\equiv (BTA)(MMG)(LMA)/(TK)^2$.

STG = Calculated tangential stress in flange, pounds per square inch, (gasket seating conditions), $\equiv [(MMG)(Y)/(TK)^2] - Z(SR)$.

SCG = Combined stress greater of .5(SHG+SRG) or .5(STG+STG).

SFA = Allowable design stress for material of flange, nozzle neck vessel or pipe wall, at atmospheric temperature (gasket seating), pounds per square inch. Select from ASME Code for required material.

PROGRAM WELD
NECK FLANGE DESIGN

ROM'S

MATH PAC

①

②

PRINTER ALPHA

③

OPTIONS _____

EQUIPMENT 9810A H.P.

Calculator

PROGRAM _____

ROM'S

①

②

③

OPTIONS _____

EQUIPMENT _____

PROGRAM _____

ROM'S

①

②

③

OPTIONS _____

EQUIPMENT _____



HEWLETT-PACKARD CALCULATOR

DESIGN OF
WELDING NECK
FLANGES

12

DESIGN OF
WELDING NECK
FLANGES

B= 0.3060*
Y= 3700.0000*
M= 2.7500*
G= 33.8888*
WM2= 120536.6068
P= 400.0000*
HP= 71670.4149
H= 360779.4146
WM1= 432449.8295
BOLTING STRESS
ATM. TEMP PSI
SA= 20000.0000*
BOLT STRESS
DESIGN TEMP-PSI
SB= 20000.0000
AM= 21.6225
NO. BOLTS= 40.0000*
ROOT AREA BOLTS= 0.5510*
RB= 22.0400
U= 436624.9147
HMIN= 0.5594
B1= 32.0000*
HD= 321699.0877
HG= 71670.4149
HT= 39000.0269
HGG= 436624.9147

PROGRAM OUTPUT

R= 1.3750*
G1= 1.1250*
C= 37.0000*
HD1= 1.9375
HG1= 1.5560
HT1= 2.0280
HG1G= 1.5560
MD= 623291.9825
MG= 111519.1655
MT= 79254.9029
MO= 814066.0509
MOG= 679388.3673
A= 39.1250*
K= 1.2227
T= 1.8298
U= 10.7399
Z= 5.0413
YS= 9.7733
GO= 0.5000*
G1/GO= 2.2500
HO= 4.0000
L= 2.7500*
H/HO= 0.6875
FIND F -V FROM
INTEGRAL FLANGE
FACTOR TABLE
F= 0.7800*
V= 0.1638*

FIND HUB STRESS
CORRECTION FACTR

FC= 1.0000*
E= 0.1950
D= 65.8889
ASSUME FLG THICK
TK= 1.0000*
ALF= 1.1950
BTAF= 1.2600
GMA= 0.6531
DEL= 0.0152
LMA= 0.6683
MM= 25439.5641
MMG= 21230.8865/
NOM. BOLT DIR.= 1.0000*
BS= 3.0000
NO. BOLTS-SAME
AS BEFORE= 40.0000*
OPERATING STRESS
SH= 30078.2679
SR= 47965.4378
ST= 6820.1798
SC= 39021.8528
SF0= 17500.0000*
SC GTR SF0 PICK
NEW THICKNESS
SR GTR SF0 PICK
NEW THICKNESS
SH GTR 1.5(SF0)
PICK NEW THICK

TYPE ERROR MESSAGE

PROGRAM OUTPUT

13

FOR GASKET SEAT

SHG= 25102.1711
 SRG= 40030.1185
 STG= 5691.8610
 SCG= 32566.1448
 SFR= 17500.0000*
 SGC GTR SFA
 NEW TK
 SGR GTR SFA
 NEW TK
ASSUME FLG THICK
 TKE= 2.00000*
 ALF= 1.3900
 BTA= 1.5200
 GMA= 0.7597
 DEL= 0.1214
 LMA= 0.8811
 MM= 25439.5641
 MMG= 21230.8865

ERROR MESSAGES

NOM. BOLT DIA.= 1.0000*
 BS= 4.0000
 NO. BOLTS-SAME
 BS BEFORE= 40.0000*
 OPERATING STRESS
 SH= 22813.3413
 SR= 10971.7913
 ST= 6845.0099
 SC= 16892.5663
 SFO= 17500.0000*
 FOR GASKET SEAT

NO ERROR MESSAGES

SHG= 19039.1415
 SRG= 9156.6371
 STG= 5712.5833
 SCG= 14097.8893
 SFR= 17500.0000*

ASSUME FLG THICK

TK=

DO NOT NEED
A NEW TR.
DESIGN SATIS-
FACTORY

Table UA-49.2

SECTION VIII - DIVISION 1 PRESSURE VESSELS (Reference 1)

TABLE UA-49.2 EFFECTIVE GASKET WIDTH

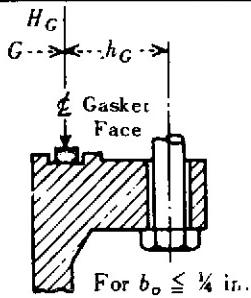
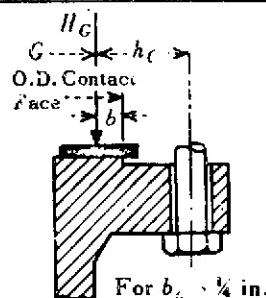
| FACING SKETCH Exaggerated | BASIC GASKET SEATING WIDTH, b_o | |
|------------------------------|---|---|
| | COLUMN I | COLUMN II |
| 1a | | |
| 1b* | $\frac{N}{2}$ | $\frac{N}{2}$ |
| 1c | | |
| 1d* | $\frac{w+T}{2}; \left(\frac{w+N}{4} \text{ max} \right)$ | $\frac{w+T}{2}; \left(\frac{w+N}{4} \text{ max} \right)$ |
| 2 | $\frac{w+N}{4}$ | $\frac{w+3N}{8}$ |
| 3 | $\frac{N}{4}$ | $\frac{3N}{8}$ |
| 4* | $\frac{3N}{8}$ | $\frac{7N}{16}$ |
| 5* | $\frac{N}{4}$ | $\frac{3N}{8}$ |
| 6 | $\frac{w}{8}$ | |

EFFECTIVE GASKET SEATING WIDTH, "b"

$$b = b_o, \text{ when } b_o \leq \frac{1}{4} \text{ in.}$$

$$b = \frac{\sqrt{b_o}}{2}, \text{ when } b_o > \frac{1}{4} \text{ in.}$$

LOCATION OF GASKET LOAD REACTION



NOTE: The gasket factors listed only apply to flanged joints in which the gasket is contained entirely within the inner edges of the bolt holes

*Where serrations do not exceed 1/64 in. depth and 1/32 in. width spacing, sketches 1b and 1d shall be used.

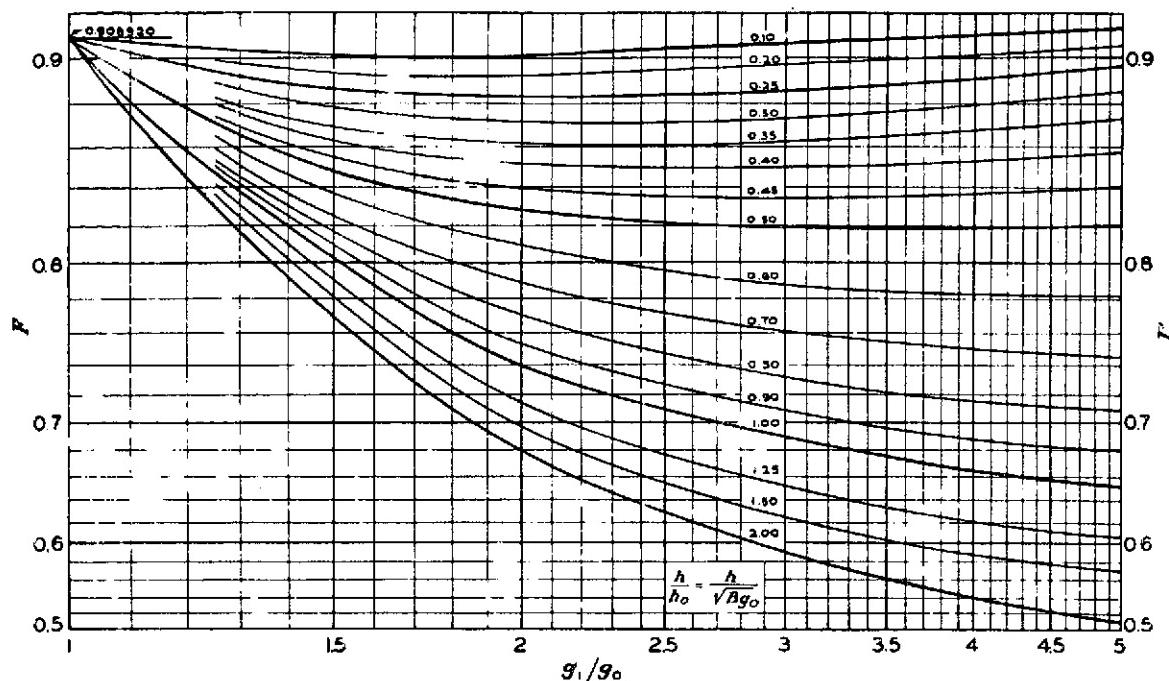
MANDATORY APPENDICES (Reference 1)

Table UA-49.1

TABLE UA-49.1
GASKET MATERIALS AND CONTACT FACINGS

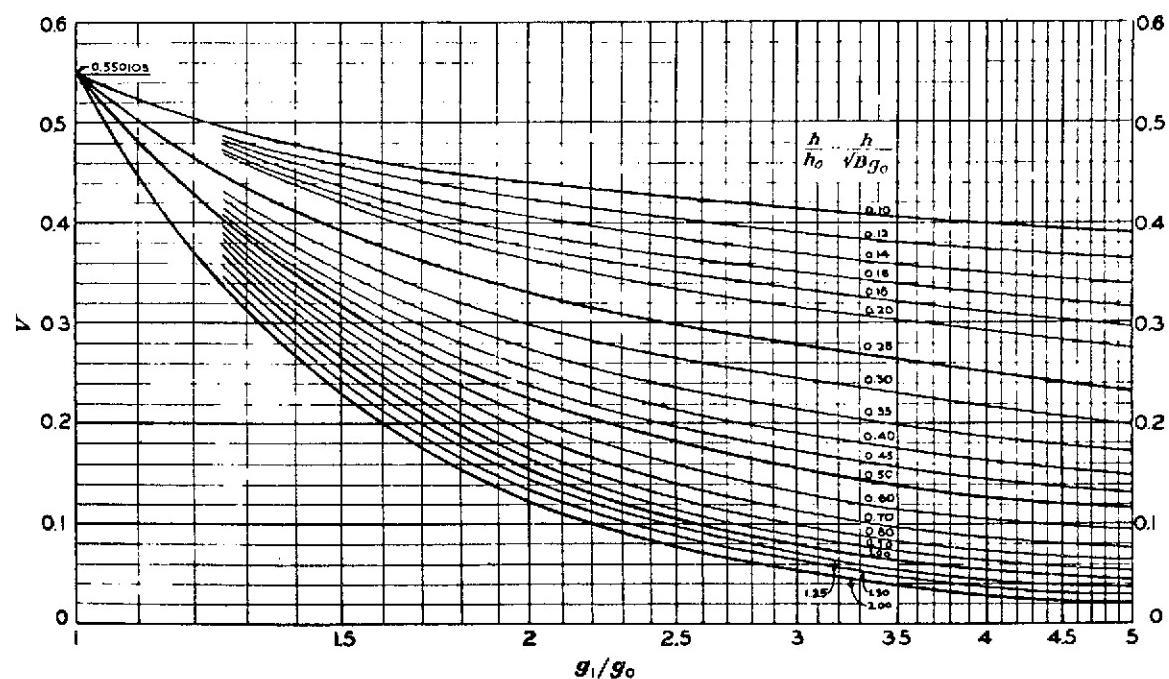
| Gasket material | | Gasket factor m | Min design seating stress γ | Sketches and notes | Refer to Table UA-49.2 | Use facing sketch | Use column |
|---|---|--|--|--------------------|-----------------------------|-------------------|------------|
| Self-Energizing Types O Rings, Metallic, Elastomer other gasket types considered as self-sealing | | 0 | 0 | — | — | — | — |
| Elastomers without fabric or a high percentage of asbestos fiber: Below 75 Shore Durometer 75 or higher Shore Durometer | | 0.50 1.00 | 0 200 | | | | |
| Asbestos with a suitable binder, i.e. the operating conditions | % thick 1/16 thick 1/32 thick | 2.00 2.75 3.50 | 1600 3700 6500 | | | | |
| Elastomers with cotton fabric insertion | | 1.25 | 400 | | 1(a, b, c, d) 4, 5 | | |
| Elastomers with asbestos fabric insertion, with or without wire reinforcement | 3-ply 2-ply 1-ply | 2.25 2.50 2.75 | 2200 2900 3700 | | | | |
| Vegetable fiber | | 1.75 | 1100 | | | | |
| Spiral-wound metal, asbestos filled | (Carbon Stainless or Monel) | 2.50 3.00 | 2900 4500 | | 1(a, b) | | II |
| Corrugated metal, asbestos inserted or Corrugated metal, jacketed asbestos filled | Soft aluminum Soft copper or brass Iron or soft steel Monel or 4-6% chrome Stainless steels | 2.50 2.75 3.00 3.25 3.50 | 2900 3700 4500 5500 6500 | | | | |
| Corrugated metal | Soft aluminum Soft copper or brass Iron or soft steel Monel or 4-6% chrome Stainless steels | 2.75 3.00 3.25 3.50 3.75 | 3700 4000 5500 6500 7600 | | 1(a, b, c, d) | | |
| Flat metal jacketed asbestos filled | Soft aluminum Soft copper or brass Iron or soft steel Monel 4-6% chrome Stainless steels | 3.25 3.50 3.75 3.50 3.75 3.75 | 5500 6500 7600 8000 9000 9000 | | 1a, 1b, 1c*, 1d*, 2* | | |
| Grooved metal | Soft aluminum Soft copper or brass Iron or soft steel Monel or 4-6% chrome Stainless steels | 3.25 3.50 3.75 3.75 4.25 | 5500 6500 7600 9000 10100 | | 1(a, b, c, d) 2, 3 | | |
| Solid flat metal | Soft aluminum Soft copper or brass Iron or soft steel Monel or 4-6% chrome Stainless steels | 4.00 4.75 5.50 6.00 6.50 | 8800 13000 18000 21800 26000 | | 1(a, b, c, d) 2, 3, 4, 5 | | I |
| Ring joint | Iron or soft steel Monel or 4-6% chrome Stainless steels | 5.50 6.00 6.50 | 18000 21800 26000 | | 6 | | |

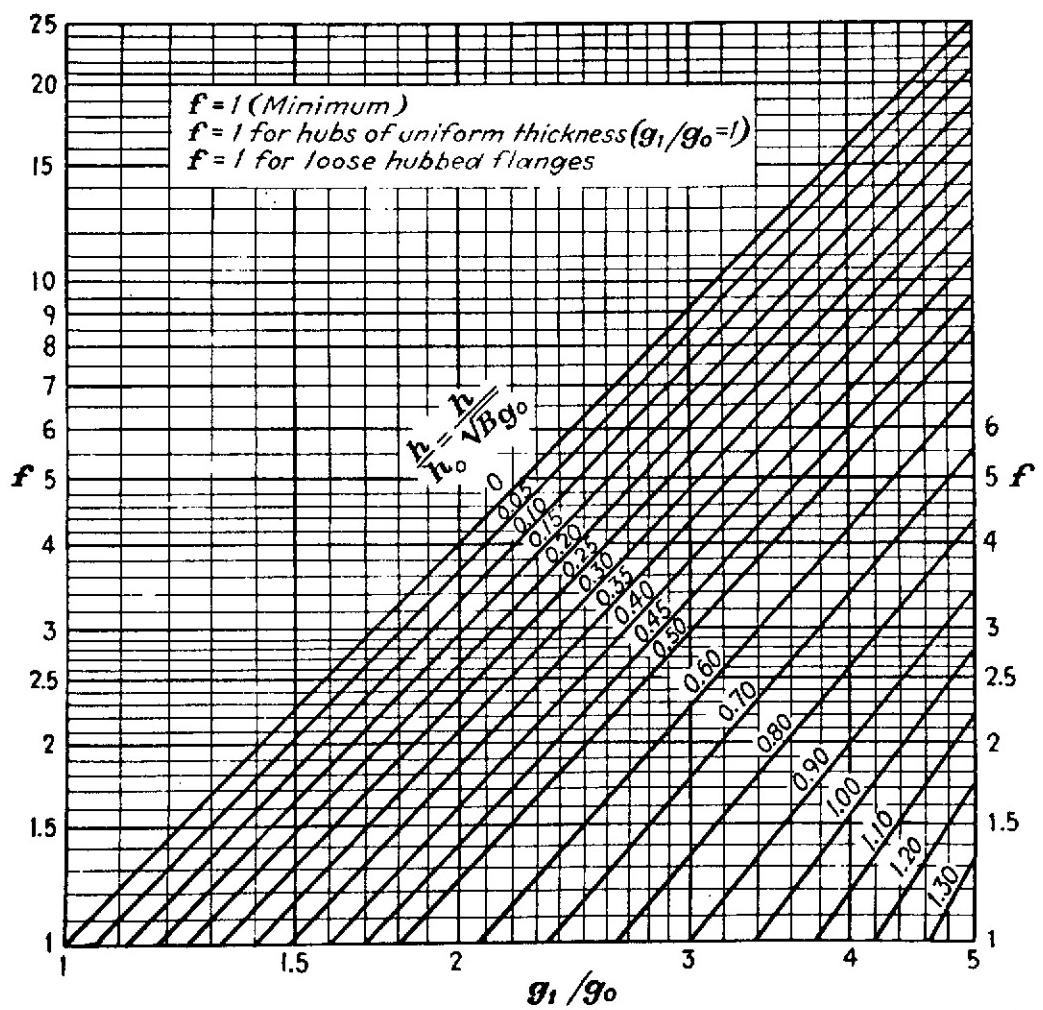
*The surface of a gasket having a lap should not be against the nubbin.

FIG. UA-61.2 VALUES OF F (Integral flange factors) (Reference 1)

Figs. UA-51.3–UA-51.5

SECTION VIII – DIVISION 1 PRESSURE VESSELS (Reference 1)

FIG. UA-61.3 VALUES OF V (Integral flange factors)

FIG. UA-51.6 VALUES OF f (Hub stress correction factor) (Reference 1)

DESIGN OF
WELDING NECK
FLANGES

18

PROGRAM

| | | |
|----------------|-----------------|-----------------|
| 0000--FMT---42 | 0056--FMT---42 | 0112--XTO---23 |
| 0001--FMT---42 | 0057--FMT---42 | 0113-- 6 ---06 |
| 0002--PNT---45 | 0058--XFR---67 | 0114--GTO---44 |
| 0003--PNT---45 | 0059--SFL---54 | 0115-- 1 ---01 |
| 0004--PNT---45 | 0060--FMT---42 | 0116-- 8 ---10 |
| 0005-- D ---63 | 0061--STP---41 | 0117-- 6 ---06 |
| 0006-- E ---60 | 0062--PNT---45 | 0118-- 4 ---04 |
| 0007--YTO---40 | 0063--XTO---23 | 0119--CNT---47 |
| 0008-- I ---65 | 0064-- 2 ---02 | 0120--CNT---47 |
| 0009-- G ---15 | 0065--FMT---42 | 0121-- UP---27 |
| 0010-- H ---73 | 0066--FMT---42 | 0122-- 2 ---02 |
| 0011--PNT---45 | 0067-- M ---70 | 0123-- X ---36 |
| 0012-- O ---71 | 0068--SFL---54 | 0124-- 11 ---56 |
| 0013-- F ---16 | 0069--FMT---42 | 0125-- X ---36 |
| 0014--CLR---20 | 0070--STP---41 | 0126--KEY---30 |
| 0015--PNT---45 | 0071--PNT---45 | 0127--FMT---42 |
| 0016--PNT---45 | 0072--XTO---23 | 0128--FMT---42 |
| 0017--IND---31 | 0073-- 3 ---03 | 0129-- H ---74 |
| 0018-- E ---60 | 0074--FMT---42 | 0130-- 1 ---56 |
| 0019-- L ---72 | 0075--FMT---42 | 0131--SFL---54 |
| 0020-- D ---63 | 0076-- G ---15 | 0132--FMT---42 |
| 0021-- I ---65 | 0077--SFL---54 | 0133--PNT---45 |
| 0022-- H ---73 | 0078--FMT---42 | 0134--XTO---23 |
| 0023-- G ---15 | 0079--STP---41 | 0135-- 7 ---07 |
| 0024--PNT---45 | 0080--PNT---45 | 0136--XFR---67 |
| 0025-- N ---73 | 0081--XTO---23 | 0137-- 4 ---04 |
| 0026-- E ---60 | 0082-- 4 ---04 | 0138--XSO---12 |
| 0027-- C ---61 | 0083--XFR---67 | 0139--RUP---22 |
| 0028-- K ---55 | 0084-- 1 ---01 | 0140-- 11 ---56 |
| 0029--PNT---45 | 0085--XFR---67 | 0141-- X ---36 |
| 0030--PNT---45 | 0086-- X ---36 | 0142--XFR---67 |
| 0031--PNT---45 | 0087-- 2 ---02 | 0143-- 6 ---06 |
| 0032--PNT---45 | 0088--XFR---67 | 0144-- X ---36 |
| 0033--PNT---45 | 0089-- X ---36 | 0145-- 4 ---04 |
| 0034--PNT---45 | 0090-- 4 ---04 | 0146--DIV---35 |
| 0035-- F ---16 | 0091--RUP---22 | 0147--KEY---30 |
| 0036-- L ---72 | 0092-- 11 ---56 | 0148--FMT---42 |
| 0037-- A ---62 | 0093-- X ---36 | 0149--FMT---42 |
| 0038-- N ---73 | 0094--KEY---30 | 0150-- H ---74 |
| 0039-- G ---15 | 0095--FMT---42 | 0151--SFL---54 |
| 0040-- E ---60 | 0096--FMT---42 | 0152--FMT---42 |
| 0041--YTO---40 | 0097--IND---31 | 0153--PNT---45 |
| 0042--PNT---45 | 0098-- M ---70 | 0154--XTO---23 |
| 0043--PNT---45 | 0099-- 2 ---02 | 0155-- 8 ---10 |
| 0044--PNT---45 | 0100--SFL---54 | 0156--RUP---22 |
| 0045--PNT---45 | 0101--FMT---42 | 0157--XFR---67 |
| 0046--CLR---20 | 0102--PNT---45 | 0158-- 7 ---07 |
| 0047--CLR---20 | 0103--XTO---23 | 0159-- + ---33 |
| 0048--CLR---20 | 0104-- 5 ---05 | 0160--KEY---30 |
| 0049-- B ---66 | 0105--FMT---42 | 0161--FMT---42 |
| 0050--SFL---54 | 0106--FMT---42 | 0162--FMT---42 |
| 0051--FMT---42 | 0107-- 11 ---56 | 0163--IND---31 |
| 0052--STP---41 | 0108--SFL---54 | 0164-- M ---70 |
| 0053--PNT---45 | 0109--FMT---42 | 0165-- 1 ---01 |
| 0054--XTO---23 | 0110--STP---41 | 0166--SFL---54 |
| 0055-- 1 ---01 | 0111--PNT---45 | 0167--FMT---42 |

DESIGN OF
WELDING NECK
FLANGES

19

| | | |
|----------------|------------------|------------------|
| 0168--PNT---45 | 0226-- E ---68 | 0285-- B ---66 |
| 0169--XTO---23 | 0227-- YTO---48 | 0286-- O ---71 |
| 0170-- 9 ---11 | 0228-- I ---65 | 0287-- L ---72 |
| 0171--FMT---42 | 0229-- G ---15 | 0288-- XTO---23 |
| 0172--FMT---42 | 0230-- H ---73 | 0289-- YTO---48 |
| 0173-- B ---66 | 0231-- CHT---47 | 0290-- SFL---54 |
| 0174-- O ---71 | 0232-- XTO---23 | 0291-- FMT---42 |
| 0175-- L ---72 | 0233-- E ---68 | 0292-- STP---41 |
| 0176--XTO---23 | 0234-- M ---70 | 0293-- PNT---45 |
| 0177-- I ---65 | 0235-- 1 ---56 | 0294-- RUP---22 |
| 0178-- N ---73 | 0236-- - ---34 | 0295-- FMT---42 |
| 0179-- G ---15 | 0237-- 1 ---56 | 0296-- FMT---42 |
| 0180--CNT---47 | 0238-- YTO---48 | 0297-- o ---13 |
| 0181--YTO---48 | 0239-- I ---65 | 0298-- O ---71 |
| 0182--XTO---23 | 0240-- CLR---20 | 0299-- O ---71 |
| 0183-- o ---13 | 0241-- YTO---48 | 0300-- XTO---23 |
| 0184-- E ---68 | 0242-- B ---66 | 0301-- PNT---45 |
| 0185--YTO---48 | 0243-- SFL---54 | 0302-- R ---62 |
| 0186--YTO---48 | 0244-- FMT---42 | 0303-- o ---13 |
| 0187--CLR---20 | 0245-- STP---41 | 0304-- E ---68 |
| 0188-- R ---62 | 0246-- PNT---45 | 0305-- R ---62 |
| 0189--XTO---23 | 0247-- XTO---23 | 0306-- PNT---45 |
| 0190-- N ---70 | 0248-- 1 ---61 | 0307-- B ---66 |
| 0191-- . ---21 | 0249-- 1 ---61 | 0308-- O ---71 |
| 0192--CNT---47 | 0250-- RUP---22 | 0309-- L ---72 |
| 0193--XTO---23 | 0251-- XFR---67 | 0310-- XTO---23 |
| 0194-- E ---68 | 0252-- 9 ---11 | 0311-- YTO---48 |
| 0195-- M ---70 | 0253-- XKEY---38 | 0312-- SFL---54 |
| 0196-- 1 ---56 | 0254-- DIV---35 | 0313-- FMT---42 |
| 0197--CNT---47 | 0255-- RUP---22 | 0314-- STP---41 |
| 0198-- 1 ---56 | 0256-- XFR---67 | 0315-- PNT---45 |
| 0199--YTO---48 | 0257-- 5 ---65 | 0316-- X ---36 |
| 0200-- I ---65 | 0258-- XKEY---38 | 0317-- XKEY---38 |
| 0201--CLR---20 | 0259-- XFR---67 | 0318-- FMT---42 |
| 0202--YTO---48 | 0260-- 1 ---61 | 0319-- FMT---42 |
| 0203-- R ---62 | 0261-- 0 ---60 | 0320-- R ---62 |
| 0204--SFL---54 | 0262-- DIV---35 | 0321-- B ---66 |
| 0205--FMT---42 | 0263-- DN---25 | 0322-- SFL---54 |
| 0206--STP---41 | 0264-- XY---52 | 0323-- FMT---42 |
| 0207--PNT---45 | 0265-- XKEY---38 | 0324-- PNT---45 |
| 0208--XTO---23 | 0266-- CNT---47 | 0325-- XTO---23 |
| 0209-- 1 ---61 | 0267-- CNT---47 | 0326-- 1 ---61 |
| 0210-- 0 ---60 | 0268-- CNT---47 | 0327-- 3 ---63 |
| 0211--FMT---42 | 0269-- FMT---42 | 0328-- RUP---22 |
| 0212--FMT---42 | 0270-- FMT---42 | 0329-- XFR---67 |
| 0213-- B ---66 | 0271-- R ---62 | 0330-- 1 ---61 |
| 0214-- O ---71 | 0272-- M ---70 | 0331-- 2 ---62 |
| 0215-- L ---72 | 0273-- SFL---54 | 0332-- + ---38 |
| 0216--XTO---23 | 0274-- FMT---42 | 0333-- . ---21 |
| 0217--CNT---47 | 0275-- PNT---45 | 0334-- 5 ---65 |
| 0218--YTO---48 | 0276-- XTO---23 | 0335-- X ---36 |
| 0219--XTO---23 | 0277-- 1 ---61 | 0336-- XFR---67 |
| 0220-- o ---13 | 0278-- 2 ---62 | 0337-- 1 ---61 |
| 0221-- E ---68 | 0279-- FMT---42 | 0338-- 0 ---60 |
| 0222--YTO---48 | 0280-- FMT---42 | 0339-- X ---36 |
| 0223--YTO---48 | 0281-- N ---73 | 0340-- XKEY---38 |
| 0224--CLR---20 | 0282-- O ---71 | 0341-- FMT---42 |
| 0225-- D ---63 | 0283-- . ---21 | 0342-- FMT---42 |
| | 0284-- PNT---45 | 0343-- IND---31 |
| | | 0344-- SFL---54 |

DESIGN OF
WELDING NECK
FLANGES

20

| | | |
|-----------------|----------------|----------------|
| 0345--FMT---42 | 0403--FMT---42 | 0461-- 1 ---01 |
| 0346--PHT---45 | 0404-- H ---74 | 0462--SFL---54 |
| 0347--XTO---23 | 0405-- D ---63 | 0463--FMT---42 |
| 0348-- 1 ---01 | 0406--SFL---54 | 0464--STP---41 |
| 0349-- 4 ---04 | 0407--FMT---42 | 0465--PNT---45 |
| 0350--XFR---67 | 0408--PHT---45 | 0466--XTO---23 |
| 0351-- 1 ---01 | 0409--XTO---23 | 0467-- 1 ---01 |
| 0352-- 3 --03 | 0410-- 1 ---01 | 0468-- 9 ---11 |
| 0353--RUP---22 | 0411-- 6 ---06 | 0469--FMT---42 |
| 0354-- 2 ---02 | 0412--RUP---22 | 0470--FMT---42 |
| 0355--DIV---35 | 0413--XFR---67 | 0471-- C ---61 |
| 0356--XFR---67 | 0414-- 7 ---07 | 0472--SFL---54 |
| 0357-- 1 ---01 | 0415--FMT---42 | 0473--FMT---42 |
| 0358-- 8 ---08 | 0416--FMT---42 | 0474--STP---41 |
| 0359-- X ---36 | 0417-- H ---74 | 0475--PNT---45 |
| 0360-- n ---56 | 0418-- G ---15 | 0476--XTO---23 |
| 0361--DIV---35 | 0419--SFL---54 | 0477-- 2 ---02 |
| 0362-- 1 ---01 | 0420--FMT---42 | 0478-- 8 ---08 |
| 0363--XFR---67 | 0421--PMT---45 | 0479--XFR---67 |
| 0364-- + ---33 | 0422--XFR---67 | 0480-- 4 ---04 |
| 0365-- 2 ---02 | 0423-- 8 ---10 | 0481--CNT---47 |
| 0366--DIV---35 | 0424--KEY---30 | 0482--CNT---47 |
| 0367--CNT---47 | 0425-- - ---34 | 0483--XTO---23 |
| 0368--XFR---67 | 0426--FMT---42 | 0484-- 2 ---02 |
| 0369-- 4 ---04 | 0427--FMT---42 | 0485-- 1 ---01 |
| 0370--DIV---35 | 0428-- H ---74 | 0486--XFR---67 |
| 0371--KEY---30 | 0429--XTO---23 | 0487-- 1 ---01 |
| 0372--FMT---42 | 0430--SFL---54 | 0488-- 8 ---10 |
| 0373--FMT---42 | 0431--FMT---42 | 0489-- UP---27 |
| 0374-- H ---73 | 0432--KEY---30 | 0490--XFR---67 |
| 0375-- M ---70 | 0433--PNT---45 | 0491-- 1 ---01 |
| 0376-- I ---65 | 0434--XTO---23 | 0492-- 9 ---11 |
| 0377-- N ---73 | 0435-- 1 ---01 | 0493-- UP---27 |
| 0378--SFL---54 | 0436-- 7 ---07 | 0494-- . ---21 |
| 0379--FMT---42 | 0437--XFR---67 | 0495-- 5 ---05 |
| 0380--PNT---45 | 0438-- 1 ---01 | 0496-- X ---36 |
| 0381--FMT---42 | 0439-- 4 ---04 | 0497-- DN---25 |
| 0382--FMT---42 | 0440--FMT---42 | 0498-- + ---33 |
| 0383-- B ---66 | 0441--FMT---42 | 0499-- DN---25 |
| 0384-- 1 ---01 | 0442-- H ---74 | 0500--FMT---42 |
| 0385--SFL---54 | 0443-- G ---15 | 0501--FMT---42 |
| 0386--FMT---42 | 0444-- G ---15 | 0502-- H ---74 |
| 0387--STP---41 | 0445--SFL---54 | 0503-- D ---63 |
| 0388--PNT---45 | 0446--FMT---42 | 0504-- 1 ---01 |
| 0389--XTO---23 | 0447--PNT---45 | 0505--SFL---54 |
| 0390-- 1 ---01 | 0448--FMT---42 | 0506--FMT---42 |
| 0391-- 5 ---05 | 0449--FMT---42 | 0507--PNT---45 |
| 0392--XSO---12 | 0450-- 8 ---13 | 0508--XTO---23 |
| 0393--RUP---22 | 0451--SFL---54 | 0509-- 2 ---02 |
| 0394-- n ---56 | 0452--FMT---42 | 0510-- 2 ---02 |
| 0395-- X ---36 | 0453--STP---41 | 0511--XFR---67 |
| 0396-- 4 ---04 | 0454--PNT---45 | 0512-- 2 ---02 |
| 0397--DIV---35 | 0455--XTO---23 | 0513-- 8 ---08 |
| 0398--XFR---67 | 0456-- 1 ---01 | 0514--XFR---67 |
| 0399-- 6 ---06 | 0457-- 8 ---10 | 0515-- . ---34 |
| 0400-- X ---36 | 0458--FMT---42 | 0516-- 2 ---02 |
| 0401-- KEY---30 | 0459--FMT---42 | 0517-- 1 ---01 |
| 0402--FMT---42 | 0460-- G ---15 | 0518--RUP---22 |
| | | 0519-- . ---21 |

DESIGN OF
WELDING NECK
FLANGES

21

0520-- 5 ---05
 0521-- X ---36
 0522-- XKEY---30
 0523-- FMT---42
 0524-- FMT---42
 0525-- H ---74
 0526-- G ---15
 0527-- 1 ---01
 0528-- SFL---54
 0529-- FMT---42
 0530-- PNT---45
 0531-- XTO---23
 0532-- 2 ---02
 0533-- 3 ---03
 0534-- RUP---22
 0535-- XFR---67
 0536-- 1 ---01
 0537-- 8 ---10
 0538-- + ---33
 0539-- XFR---67
 0540-- 1 ---01
 0541-- 9 ---11
 0542-- + ---33
 0543-- . ---21
 0544-- 5 ---05
 0545-- X ---36
 0546-- CNT---47
 0547-- CNT---47
 0548-- XKEY---30
 0549-- FMT---42
 0550-- FMT---42
 0551-- H ---74
 0552-- XTO---23
 0553-- 1 ---01
 0554-- SFL---54
 0555-- FMT---42
 0556-- PNT---45
 0557-- XTO---23
 0558-- 2 ---02
 0559-- 4 ---04
 0560-- XFR---67
 0561-- 2 ---02
 0562-- 3 ---03
 0563-- FMT---42
 0564-- FMT---42
 0565-- H ---74
 0566-- G ---15
 0567-- 1 ---01
 0568-- G ---15
 0569-- SFL---54
 0570-- FMT---42
 0571-- PNT---45
 0572-- XFR---67
 0573-- 1 ---01
 0574-- 6 ---06
 0575-- XFR---67
 0576-- X ---36
 0577-- 2 ---02

0578-- 2 ---02
 0579-- FMT---42
 0580-- FMT---42
 0581-- M ---70
 0582-- D ---63
 0583-- SFL---54
 0584-- FMT---42
 0585-- PNT---45
 0586-- RUP---22
 0587-- XFR---67
 0588-- 7 ---07
 0589-- XFR---67
 0590-- X ---36
 0591-- 2 ---02
 0592-- 3 ---03
 0593-- FMT---42
 0594-- FMT---42
 0595-- M ---70
 0596-- G ---15
 0597-- SFL---54
 0598-- FMT---42
 0599-- PNT---45
 0600-- + ---33
 0601-- XFR---67
 0602-- 1 ---01
 0603-- 7 ---07
 0604-- XFR---67
 0605-- X ---36
 0606-- 2 ---02
 0607-- 4 ---04
 0608-- FMT---42
 0609-- FMT---42
 0610-- M ---70
 0611-- XTO---23
 0612-- SFL---54
 0613-- FMT---42
 0614-- PNT---45
 0615-- + ---33
 0616-- XKEY---30
 0617-- FMT---42
 0618-- FMT---42
 0619-- M ---70
 0620-- O ---71
 0621-- SFL---54
 0622-- FMT---42
 0623-- PNT---45
 0624-- XTO---23
 0625-- 2 ---02
 0626-- 5 ---05
 0627-- XFR---67
 0628-- 1 ---01
 0629-- 4 ---04
 0630-- XFR---67
 0631-- X ---36
 0632-- 2 ---02
 0633-- 3 ---03
 0634-- FMT---42
 0635-- FMT---42
 0636-- M ---70
 0637-- O ---71
 0638-- G ---15
 0639-- SFL---54
 0640-- FMT---42
 0641-- PNT---45
 0642-- XTO---23
 0643-- 2 ---02
 0644-- 6 ---06
 0645-- FMT---42
 0646-- FMT---42
 0647-- R ---62
 0648-- SFL---54
 0649-- FMT---42
 0650-- STP---41
 0651-- PNT---45
 0652-- XTO---23
 0653-- 2 ---02
 0654-- 7 ---07
 0655-- RUP---22
 0656-- XFR---67
 0657-- 1 ---01
 0658-- 5 ---05
 0659-- DIV---35
 0660-- XKEY---30
 0661-- FMT---42
 0662-- FMT---42
 0663-- K ---55
 0664-- SFL---54
 0665-- FMT---42
 0666-- PNT---45
 0667-- XTO---23
 0668-- 8 ---08
 0669-- XSO---12
 0670-- XTO---23
 0671-- 1 ---01
 0672-- CNT---47
 0673-- XFR---67
 0674-- 8 ---08
 0675-- 0 ---00
 0676-- 0 ---00
 0677-- K ---55
 0678-- 4 ---04
 0679-- XTO---23
 0680-- 0 ---00
 0681-- 2 ---02
 0682-- UP---27
 0683-- 8 ---10
 0684-- . ---21
 0685-- 5 ---05
 0686-- 5 ---05
 0687-- 2 ---02
 0688-- 4 ---04
 0689-- 6 ---06
 0690-- X ---36
 0691-- 1 ---01
 0692-- + ---33
 0693-- XFR---67
 0694-- 8 ---08
 0695-- 0 ---00
 0696-- 1 ---01

DESIGN OF
WELDING NECK
FLANGES

22

| | | |
|-----------------|-----------------|-----------------|
| 0697-- X ---36 | 0756-- 1 ---01 | 0816-- 2 ---02 |
| 0698-- 1 ---01 | 0757-- UP---27 | 0817-- UP---27 |
| 0699-- . ---34 | 0758-- 1 ---01 | 0818-- XFR---67 |
| 0700-- YTO---40 | 0759-- CHS---32 | 0819-- 0 ---00 |
| 0701-- 3 ---03 | 0760-- XFR---67 | 0820-- 0 ---00 |
| 0702-- 3 ---03 | 0761-- + ---33 | 0821-- 1 ---01 |
| 0703-- CNT---47 | 0762-- 0 ---00 | 0822-- X ---36 |
| 0704-- CNT---47 | 0763-- 0 ---00 | 0823-- 5 ---05 |
| 0705-- CNT---47 | 0764-- X ---36 | 0824-- . ---21 |
| 0706-- CNT---47 | 0765-- 1 ---01 | 0825-- ? ---07 |
| 0707-- 1 ---01 | 0766-- . ---21 | 0826-- 1 ---01 |
| 0708-- . ---21 | 0767-- 3 ---03 | 0827-- 6 ---06 |
| 0709-- 9 ---11 | 0768-- 6 ---06 | 0828-- 9 ---11 |
| 0710-- 4 ---04 | 0769-- 1 ---01 | 0829-- X ---36 |
| 0711-- 4 ---04 | 0770-- 3 ---03 | 0830-- 1 ---01 |
| 0712-- 8 ---10 | 0771-- 6 ---06 | 0831-- CHS---32 |
| 0713-- UP---27 | 0772-- X ---36 | 0832-- XFR---67 |
| 0714-- XFR---67 | 0773-- DN---25 | 0833-- + ---33 |
| 0715-- 0 ---00 | 0774-- DIV---35 | 0834-- 0 ---00 |
| 0716-- 0 ---00 | 0775-- KEY---30 | 0835-- 0 ---00 |
| 0717-- 1 ---01 | 0776-- FMT---42 | 0836-- 1 ---01 |
| 0718-- X ---36 | 0777-- FMT---42 | 0837-- DIV---35 |
| 0719-- 1 ---01 | 0778-- 1/X---17 | 0838-- . ---21 |
| 0720-- . ---21 | 0779-- SFL---54 | 0839-- 6 ---06 |
| 0721-- 0 ---00 | 0780-- FMT---42 | 0840-- 6 ---06 |
| 0722-- 4 ---04 | 0781-- PHT---45 | 0841-- 8 ---10 |
| 0723-- 7 ---07 | 0782-- XTO---23 | 0842-- 4 ---04 |
| 0724-- 2 ---02 | 0783-- 0 ---00 | 0843-- 5 ---05 |
| 0725-- + ---33 | 0784-- 3 ---03 | 0844-- + ---33 |
| 0726-- 1 ---01 | 0785-- 1 ---01 | 0845-- 1 ---01 |
| 0727-- CHS---32 | 0786-- XFR---67 | 0846-- CHS---32 |
| 0728-- XFR---67 | 0787-- 0 ---00 | 0847-- XFR---67 |
| 0729-- + ---33 | 0788-- 0 ---00 | 0848-- + ---33 |
| 0730-- 0 ---00 | 0789-- 1 ---01 | 0849-- 0 ---00 |
| 0731-- 0 ---00 | 0790-- UP---27 | 0850-- 0 ---00 |
| 0732-- 0 ---00 | 0791-- 1 ---01 | 0851-- DIV---35 |
| 0733-- X ---36 | 0792-- + ---33 | 0852-- KEY---30 |
| 0734-- DN---25 | 0793-- XFR---67 | 0853-- FMT---42 |
| 0735-- DIV---35 | 0794-- 0 ---00 | 0854-- FMT---42 |
| 0736-- KEY---30 | 0795-- 0 ---00 | 0855-- XFR---67 |
| 0737-- FMT---42 | 0796-- 1 ---01 | 0856-- YTO---40 |
| 0738-- FMT---42 | 0797-- UP---27 | 0857-- SFL---54 |
| 0739-- XTO---23 | 0798-- 1 ---01 | 0858-- FMT---42 |
| 0740-- SFL---54 | 0799-- . ---34 | 0859-- PHT---45 |
| 0741-- FMT---42 | 0800-- DN---25 | 0860-- XTO---23 |
| 0742-- PHT---45 | 0801-- DIV---35 | 0861-- 0 ---00 |
| 0743-- XTO---23 | 0802-- KEY---30 | 0862-- 3 ---03 |
| 0744-- 2 ---02 | 0803-- FMT---42 | 0863-- 0 ---00 |
| 0745-- 8 ---10 | 0804-- FMT---42 | 0864-- FMT---42 |
| 0746-- XFR---67 | 0805-- XSO---12 | 0865-- FMT---42 |
| 0747-- 0 ---00 | 0806-- SFL---54 | 0866-- 6 ---15 |
| 0748-- 3 ---03 | 0807-- FMT---42 | 0867-- 0 ---71 |
| 0749-- 3 ---03 | 0808-- PHT---45 | 0868-- SFL---54 |
| 0750-- UP---27 | 0809-- XTO---23 | 0869-- FMT---42 |
| 0751-- 1 ---01 | 0810-- 0 ---00 | 0870-- STP---41 |
| 0752-- CHS---32 | 0811-- 2 ---02 | 0871-- PHT---45 |
| 0753-- XFR---67 | 0812-- 9 ---11 | 0872-- XTO---23 |
| 0754-- + ---33 | 0813-- XFR---67 | 0873-- 3 ---03 |
| 0755-- 0 ---00 | 0814-- 0 ---00 | 0874-- 2 ---02 |
| | 0815-- 0 ---00 | 0875-- XFR---67 |

DESIGN OF
WELDING NECK
FLANGES

23

| | | |
|----------------|----------------|----------------|
| 0876-- 1 ---01 | 0935--CNT---47 | 0994-- 3 ---03 |
| 0877-- 9 ---11 | 0936-- - ---34 | 0995-- 6 ---06 |
| 0878--XFR---67 | 0937--INT---64 | 0996--FMT---42 |
| 0879--DIV---35 | 0938--CNT---47 | 0997--FMT---42 |
| 0880-- 3 ---03 | 0939--CNT---47 | 0998-- F ---16 |
| 0881-- 2 ---02 | 0940-- F ---16 | 0999-- I ---65 |
| 0882--GTO---44 | 0941-- o ---13 | 1000-- H ---73 |
| 0883-- 1 ---01 | 0942-- O ---71 | 1001-- D ---63 |
| 0884-- 8 ---18 | 0943-- M ---70 | 1002--CNT---47 |
| 0885-- 3 ---03 | 0944--CNT---47 | 1003-- H ---74 |
| 0886-- 7 ---07 | 0945-- I ---65 | 1004--1/X---17 |
| 0887--CNT---47 | 0946-- N ---73 | 1005-- B ---66 |
| 0888--PNT---45 | 0947--XTO---23 | 1006--CNT---47 |
| 0889--XFR---67 | 0948-- E ---60 | 1007--YTO---40 |
| 0890-- 1 ---01 | 0949-- G ---15 | 1008--XTO---23 |
| 0891-- 5 ---05 | 0950-- o ---13 | 1009-- a ---13 |
| 0892--XFR---67 | 0951-- R ---62 | 1010-- E ---60 |
| 0893-- X ---36 | 0952-- L ---72 | 1011--YTO---40 |
| 0894-- 3 ---03 | 0953--CNT---47 | 1012--YTO---40 |
| 0895-- 2 ---02 | 0954-- F ---16 | 1013--CNT---47 |
| 0896-- r ---76 | 0955-- L ---72 | 1014-- C ---61 |
| 0897--FMT---42 | 0956-- R ---62 | 1015-- O ---71 |
| 0898--FMT---42 | 0957-- N ---73 | 1016-- a ---13 |
| 0899-- H ---74 | 0958-- G ---15 | 1017-- o ---13 |
| 0900-- 0 ---71 | 0959-- E ---60 | 1018-- E ---60 |
| 0901--SFL---54 | 0960--CNT---47 | 1019-- C ---61 |
| 0902--FMT---42 | 0961-- F ---16 | 1020--XTO---23 |
| 0903--PNT---45 | 0962-- R ---62 | 1021-- I ---65 |
| 0904--XTO---23 | 0963-- C ---61 | 1022-- O ---71 |
| 0905-- 3 ---03 | 0964--XTO---23 | 1023-- N ---73 |
| 0906-- 4 ---04 | 0965-- O ---71 | 1024--CNT---47 |
| 0907--FMT---42 | 0966-- o ---13 | 1025-- F ---16 |
| 0908--FMT---42 | 0967--CNT---47 | 1026-- R ---62 |
| 0909-- L ---72 | 0968--XTO---23 | 1027-- C ---61 |
| 0910--SFL---54 | 0969-- R ---62 | 1028--XTO---23 |
| 0911--FMT---42 | 0970-- B ---66 | 1029-- o ---13 |
| 0912--STP---41 | 0971-- L ---72 | 1030--CLR---20 |
| 0913--PNT---45 | 0972-- E ---60 | 1031-- F ---16 |
| 0914--RUP---22 | 0973--CLR---20 | 1032-- C ---61 |
| 0915--XFR---67 | 0974--CLR---20 | 1033--SFL---54 |
| 0916-- 3 ---03 | 0975-- F ---16 | 1034--FMT---42 |
| 0917-- 4 ---04 | 0976--CNT---47 | 1035--STP---41 |
| 0918--DIV---35 | 0977--SFL---54 | 1036--PNT---45 |
| 0919--KEY---30 | 0978--FMT---42 | 1037--XTO---23 |
| 0920--GTO---44 | 0979--CNT---47 | 1038-- O ---00 |
| 0921-- 1 ---01 | 0980--STP---41 | 1039-- 2 ---02 |
| 0922-- 8 ---18 | 0981--PNT---45 | 1040-- 1 ---01 |
| 0923-- 5 ---05 | 0982--XTO---23 | 1041--XFR---67 |
| 0924-- 1 ---01 | 0983-- 3 ---03 | 1042-- 3 ---03 |
| 0925--CNT---47 | 0984-- 5 ---05 | 1043-- 5 ---05 |
| 0926--PNT---45 | 0985--FMT---42 | 1044--XFR---67 |
| 0927--FMT---42 | 0986--FMT---42 | 1045--DIV---35 |
| 0928--FMT---42 | 0987--INT---64 | 1046-- 3 ---03 |
| 0929-- F ---16 | 0988--CNT---47 | 1047-- 4 ---04 |
| 0930-- I ---65 | 0989--SFL---54 | 1048--FNT---42 |
| 0931-- N ---73 | 0990--FMT---42 | 1049--FMT---42 |
| 0932-- D ---63 | 0991--STP---41 | 1050-- E ---60 |
| 0933--CNT---47 | 0992--PHT---45 | 1051--SFL---54 |
| 0934-- F ---16 | 0993--XTO---23 | 1052--FMT---42 |
| | | 1053--PNT---45 |

DESIGN OF
WELDING NECK
FLANGES

24

| | | |
|----------------|----------------|----------------|
| 1054--XTO---23 | 1113--RUP---22 | 1172--XFR---67 |
| 1055-- 3 ---03 | 1114-- 1 ---01 | 1173-- 3 ---03 |
| 1056-- 7 ---07 | 1115-- + ---33 | 1174-- 9 ---11 |
| 1057--XFR---67 | 1116--KEY---30 | 1175--XSO---12 |
| 1058-- 3 ---03 | 1117--FMT---42 | 1176--RUP---22 |
| 1059-- 2 ---02 | 1118--FMT---42 | 1177--XFR---67 |
| 1060--XSO---12 | 1119-- A ---62 | 1178-- 3 ---03 |
| 1061--XFR---67 | 1120-- L ---72 | 1179-- 9 ---11 |
| 1062-- X ---36 | 1121-- F ---16 | 1180-- X ---36 |
| 1063-- 3 ---03 | 1122--SFL---54 | 1181--XFR---67 |
| 1064-- 4 ---04 | 1123--FMT---42 | 1182-- 3 ---03 |
| 1065--XFR---67 | 1124--PNT---45 | 1183-- 8 ---10 |
| 1066-- X ---36 | 1125--XTO---23 | 1184--DIV---35 |
| 1067-- 3 ---03 | 1126-- 4 ---04 | 1185--KEY---30 |
| 1068-- 1 ---01 | 1127-- 0 ---00 | 1186--FMT---42 |
| 1069--XFR---67 | 1128--XFR---67 | 1187--FMT---42 |
| 1070--DIV---35 | 1129-- 3 ---03 | 1188-- D ---63 |
| 1071-- 3 ---03 | 1130-- 9 ---11 | 1189-- E ---60 |
| 1072-- 6 ---06 | 1131--XFR---67 | 1190-- L ---72 |
| 1073--FMT---42 | 1132-- X ---36 | 1191--SFL---54 |
| 1074--FMT---42 | 1133-- 3 ---03 | 1192--FMT---42 |
| 1075-- D ---63 | 1134-- 7 ---07 | 1193--PNT---45 |
| 1076--SFL---54 | 1135--RUP---22 | 1194--RUP---22 |
| 1077--FMT---42 | 1136-- 4 ---04 | 1195--XFR---67 |
| 1078--PNT---45 | 1137-- X ---36 | 1196-- 4 ---04 |
| 1079--XTO---23 | 1138-- 3 ---03 | 1197-- 2 ---02 |
| 1080-- 3 ---03 | 1139--DIV---35 | 1198-- + ---33 |
| 1081-- 8 ---10 | 1140-- 1 ---01 | 1199--KEY---30 |
| 1082--FMT---42 | 1141-- + ---33 | 1200--FMT---42 |
| 1083--FMT---42 | 1142--KEY---30 | 1201--FMT---42 |
| 1084-- A ---62 | 1143--FMT---42 | 1202-- L ---72 |
| 1085--YTO---40 | 1144--FMT---42 | 1203-- M ---70 |
| 1086--YTO---40 | 1145-- B ---66 | 1204-- A ---62 |
| 1087--1/X---17 | 1146--XTO---23 | 1205--FMT---42 |
| 1088-- M ---70 | 1147-- A ---62 | 1206--PNT---45 |
| 1089-- E ---60 | 1148--SFL---54 | 1207--XTO---23 |
| 1090--CNT---47 | 1149--FMT---42 | 1208-- 4 ---04 |
| 1091-- F ---16 | 1150--PNT---45 | 1209-- 3 ---03 |
| 1092-- L ---72 | 1151--XTO---23 | 1210--XFR---67 |
| 1093-- G ---15 | 1152-- 4 ---04 | 1211-- 2 ---02 |
| 1094--CNT---47 | 1153-- 1 ---01 | 1212-- 5 ---05 |
| 1095--XTO---23 | 1154--XFR---67 | 1213--XFR---67 |
| 1096-- H ---74 | 1155-- 4 ---04 | 1214--DIV---35 |
| 1097-- I ---65 | 1156-- 0 ---00 | 1215-- 1 ---01 |
| 1098-- C ---61 | 1157--XFR---67 | 1216-- 5 ---05 |
| 1099-- K ---55 | 1158--DIV---35 | 1217--FMT---42 |
| 1100--XTO---23 | 1159-- 2 ---02 | 1218--FMT---42 |
| 1101-- K ---55 | 1160-- 0 ---10 | 1219-- M ---70 |
| 1102--SFL---54 | 1161--FMT---42 | 1220-- M ---70 |
| 1103--FMT---42 | 1162--FMT---42 | 1221--FMT---42 |
| 1104--STP---41 | 1163-- G ---15 | 1222--PNT---45 |
| 1105--PNT---45 | 1164-- M ---70 | 1223--XTO---23 |
| 1106--XTO---23 | 1165-- A ---62 | 1224-- 4 ---04 |
| 1107-- 3 ---03 | 1166--SFL---54 | 1225-- 4 ---04 |
| 1108-- 9 ---11 | 1167--FMT---42 | 1226--XFR---67 |
| 1109--XFR---67 | 1168--PNT---45 | 1227-- 2 ---02 |
| 1110-- X ---36 | 1169--XTO---23 | 1228-- 6 ---06 |
| 1111-- 3 ---03 | 1170-- 4 ---04 | 1229--XFR---67 |
| 1112-- 7 ---07 | 1171-- 2 ---02 | 1230--DIV---35 |

DESIGN OF
WELDING NECK
FLANGES

25

| | | |
|----------------|----------------|----------------|
| 1233--FMT---42 | 1292--CNT---47 | 1352--XTO---23 |
| 1234--FMT---42 | 1293-- R ---66 | 1353-- I ---65 |
| 1235-- M ---70 | 1294-- O ---71 | 1354-- N ---73 |
| 1236-- M ---70 | 1295-- L ---72 | 1355-- G ---15 |
| 1237-- G ---15 | 1296--XTO---23 | 1356--CNT---47 |
| 1238--FMT---42 | 1297--YTO---40 | 1357--YTO---40 |
| 1239--PNT---45 | 1298-- - ---34 | 1358--XTO---23 |
| 1240--XTO---23 | 1299--YTO---40 | 1359-- a ---13 |
| 1241-- 4 ---84 | 1300-- R ---62 | 1360-- E ---60 |
| 1242-- 5 ---85 | 1301-- M ---70 | 1361--YTO---40 |
| 1243--FMT---42 | 1302-- E ---66 | 1362--YTO---40 |
| 1244--FMT---42 | 1303--CLR---20 | 1363--CLR---20 |
| 1245-- N ---70 | 1304-- A ---62 | 1364--YTO---40 |
| 1246-- O ---71 | 1305--YTO---40 | 1365-- H ---74 |
| 1247-- M ---70 | 1306--CNT---47 | 1366--SFL---54 |
| 1248-- . ---21 | 1307-- B ---66 | 1367--FMT---42 |
| 1249--CNT---47 | 1308-- E ---60 | 1368--PNT---45 |
| 1250-- B ---66 | 1309-- F ---16 | 1369--XTO---23 |
| 1251-- O ---71 | 1310-- O ---71 | 1370-- 4 ---84 |
| 1252-- L ---72 | 1311-- a ---13 | 1371-- 7 ---67 |
| 1253--XTO---23 | 1312-- E ---60 | 1372--XFR---67 |
| 1254--CNT---47 | 1313--SFL---54 | 1373-- 4 ---84 |
| 1255-- D ---63 | 1314--FMT---42 | 1374-- 1 ---81 |
| 1256-- I ---65 | 1315--STP---41 | 1375--XFR---67 |
| 1257-- A ---62 | 1316--PNT---45 | 1376-- X ---36 |
| 1258-- . ---21 | 1317--DIV---35 | 1377-- 4 ---84 |
| 1259--SFL---54 | 1318--XFR---67 | 1378-- 4 ---84 |
| 1260--FMT---42 | 1319-- 4 ---84 | 1379--XFR---67 |
| 1261--STP---41 | 1320-- 6 ---66 | 1380--DIV---35 |
| 1262--PNT---45 | 1321--XYY---52 | 1381-- 4 ---84 |
| 1263-- UP---27 | 1322--GTO---44 | 1382-- 3 ---83 |
| 1264-- 2 ---62 | 1323--S/R---77 | 1383--XFR---67 |
| 1265-- X ---36 | 1324--LBL---51 | 1384--DIV---35 |
| 1266--XFR---67 | 1325-- J ---75 | 1385-- 3 ---83 |
| 1267-- 3 ---83 | 1326--XFR---67 | 1386-- 9 ---11 |
| 1268-- 9 ---11 | 1327-- 4 ---84 | 1387--XFR---67 |
| 1269-- + ---33 | 1328-- 4 ---84 | 1388--DIV---35 |
| 1270--KEY---30 | 1329--XFR---67 | 1389-- 3 ---83 |
| 1271--FMT---42 | 1330--DIV---35 | 1390-- 9 ---11 |
| 1272--FMT---42 | 1331-- 4 ---84 | 1391--FMT---42 |
| 1273-- B ---66 | 1332-- 3 ---83 | 1392--FMT---42 |
| 1274--YTO---40 | 1333--XFR---67 | 1393--YTO---40 |
| 1275--SFL---54 | 1334--DIV---35 | 1394-- o ---13 |
| 1276--FMT---42 | 1335-- 1 ---81 | 1395--SFL---54 |
| 1277--PNT---45 | 1336-- 9 ---11 | 1396--FMT---42 |
| 1278--XTO---23 | 1337--XFR---67 | 1397--PNT---45 |
| 1279-- 4 ---84 | 1338--DIV---35 | 1398--XTO---23 |
| 1280-- 6 ---66 | 1339-- 1 ---81 | 1399-- 4 ---84 |
| 1281-- n ---56 | 1340-- 9 ---11 | 1400-- 8 ---10 |
| 1282-- UP---27 | 1341--XFR---67 | 1401--XFR---67 |
| 1283--XFR---67 | 1342-- X ---36 | 1402-- 4 ---84 |
| 1284-- 2 ---62 | 1343-- 2 ---62 | 1403-- 4 ---84 |
| 1285-- 8 ---88 | 1344-- 1 ---81 | 1404--XFR---67 |
| 1286-- X ---36 | 1345--FMT---42 | 1405-- X ---36 |
| 1287--FMT---42 | 1346--FMT---42 | 1406-- 3 ---83 |
| 1288--FMT---42 | 1347-- 0 ---71 | 1407-- 8 ---80 |
| 1289-- N ---73 | 1348-- 4 ---56 | 1408--XFR---67 |
| 1290-- O ---71 | 1349-- E ---60 | 1409--DIV---35 |
| 1291-- . ---21 | 1350-- o ---13 | 1410-- 3 ---83 |
| | 1351-- R ---62 | 1411-- 9 ---11 |

DESIGN OF
WELDING NECK
FLANGES

26

| | | |
|----------------|----------------|-----------------|
| 1412--XFR---67 | 1471--FMT---42 | 1530--YTO---48 |
| 1413--DIV---35 | 1472--FMT---42 | 1531-- a ---13 |
| 1414-- 3 ---03 | 1473--YTO---40 | 1532--CNT---47 |
| 1415-- 8 ---11 | 1474-- F ---16 | 1533-- G ---15 |
| 1416-- UP---27 | 1475-- O ---71 | 1534-- XTO---23 |
| 1417--XFR---67 | 1476--SFL---54 | 1535-- o ---13 |
| 1418-- 4 ---04 | 1477--FMT---42 | 1536--CNT---47 |
| 1419-- 8 ---10 | 1478--STP---41 | 1537--YTO---48 |
| 1420-- UP---27 | 1479--PHT---45 | 1538-- F ---16 |
| 1421--XFR---67 | 1480--X>Y---53 | 1539-- O ---71 |
| 1422-- 2 ---02 | 1481-- 1 ---01 | 1540--CNT---47 |
| 1423-- 2 ---11 | 1482-- 5 ---05 | 1541-- n ---56 |
| 1424-- X ---36 | 1483-- 1 ---01 | 1542-- I ---65 |
| 1425-- DN---25 | 1484-- 9 ---11 | 1543-- C ---61 |
| 1426-- . ---34 | 1485--FMT---42 | 1544-- K ---55 |
| 1427--KEY---30 | 1486--FMT---42 | 1545--CNT---47 |
| 1428--FMT---42 | 1487--YTO---40 | 1546-- N ---73 |
| 1429--FMT---42 | 1488-- C ---61 | 1547-- E ---60 |
| 1430--YTO---48 | 1489--CNT---47 | 1548--IND---31 |
| 1431--XTO---23 | 1490-- G ---15 | 1549--CNT---47 |
| 1432--SFL---54 | 1491--XTO---23 | 1550--XTO---23 |
| 1433--FMT---42 | 1492-- a ---13 | 1551-- H ---74 |
| 1434--PNT---45 | 1493--CNT---47 | 1552-- I ---65 |
| 1435--XTO---23 | 1494--YTO---40 | 1553-- C ---61 |
| 1436-- 0 ---00 | 1495-- F ---16 | 1554-- K ---55 |
| 1437-- 9 ---11 | 1496-- O ---71 | 1555-- N ---73 |
| 1438--XFR---67 | 1497--CNT---47 | 1556-- E ---60 |
| 1439-- 4 ---04 | 1498-- n ---56 | 1557--YTO---48 |
| 1440-- 7 ---07 | 1499-- I ---65 | 1558--YTO---40 |
| 1441-- UP---27 | 1500-- C ---61 | 1559--CLR---20 |
| 1442--XFR---67 | 1501-- K ---55 | 1560--CLR---20 |
| 1443-- 4 ---04 | 1502--CNT---47 | 1561--FMT---42 |
| 1444-- 8 ---10 | 1503-- N ---73 | 1562--XFR---67 |
| 1445-- + ---33 | 1504-- E ---60 | 1563-- 0 ---00 |
| 1446-- . ---21 | 1505--IND---31 | 1564-- 0 ---00 |
| 1447-- 5 ---05 | 1506--CNT---47 | 1565-- 9 ---11 |
| 1448-- X ---36 | 1507--XTO---23 | 1566--X<Y---52 |
| 1449--XFR---67 | 1508-- H ---74 | 1567-- 1 ---01 |
| 1450-- 4 ---04 | 1509-- I ---65 | 1568-- 6 ---06 |
| 1451-- 7 ---07 | 1510-- C ---61 | 1569-- 0 ---00 |
| 1452-- UP---27 | 1511-- K ---55 | 1570-- 5 ---05 |
| 1453--XFR---67 | 1512-- N ---73 | 1571--FMT---42 |
| 1454-- 0 ---00 | 1513-- E ---60 | 1572--FMT---42 |
| 1455-- 9 ---11 | 1514--YTO---40 | 1573--YTO---40 |
| 1456-- + ---33 | 1515--YTO---40 | 1574--XTO---23 |
| 1457-- . ---21 | 1516--CLR---20 | 1575--CNT---47 |
| 1458-- 5 ---05 | 1517--CLR---20 | 1576-- G ---15 |
| 1459-- X ---36 | 1518--FMT---42 | 1577--XTO---23 |
| 1460-- DN---25 | 1519-- UP---27 | 1578-- a ---13 |
| 1461--X<Y---52 | 1520--XFR---67 | 1579--CNT---47 |
| 1462-- 1 ---01 | 1521-- 4 ---04 | 1580--YTO---40 |
| 1463-- 8 ---10 | 1522-- 8 ---18 | 1581-- F ---16 |
| 1464-- 7 ---07 | 1523--X<Y---52 | 1582-- 0 ---71 |
| 1465-- 8 ---10 | 1524-- 1 ---01 | 1583--CNT---47 |
| 1466--GTO---44 | 1525-- 5 ---05 | 1584-- n ---56 |
| 1467-- 1 ---01 | 1526-- 6 ---06 | 1585-- I ---65 |
| 1468-- 8 ---10 | 1527-- 2 ---02 | 1586-- C ---61 |
| 1469-- 7 ---07 | 1528--FMT---42 | 1587-- K ---55 |
| 1470-- 9 ---11 | 1529--FMT---42 | 1588--CNT---47 |

DESIGN OF
WELDING NECK
FLANGES

27

| | | |
|-----------------|-----------------|-----------------|
| 1650-- I ---65 | 1590-- E ---60 | 1710-- S ---85 |
| 1651-- C ---61 | 1591-- IND---31 | 1711-- XFR---67 |
| 1652-- K ---55 | 1592-- CNT---47 | 1712-- DIV---35 |
| 1653-- CLR---20 | 1593-- YTO---23 | 1713-- 4 ---84 |
| 1654-- CLR---20 | 1594-- H ---74 | 1714-- 3 ---83 |
| 1655-- FMT---42 | 1595-- I ---65 | 1715-- XFR---67 |
| 1656-- XFR---67 | 1596-- C ---61 | 1716-- DIV---35 |
| 1657-- 4 ---84 | 1597-- K ---55 | 1717-- 3 ---83 |
| 1658-- 5 ---85 | 1598-- N ---73 | 1718-- 9 ---11 |
| 1659-- XFR---67 | 1599-- E ---60 | 1719-- XFR---67 |
| 1660-- DIV---35 | 1600-- YTO---40 | 1720-- DIV---35 |
| 1661-- 4 ---84 | 1601-- YTO---40 | 1721-- 3 ---83 |
| 1662-- 3 ---83 | 1602-- CLR---20 | 1722-- 9 ---11 |
| 1663-- XFR---67 | 1603-- CLR---20 | 1723-- FMT---42 |
| 1664-- DIV---35 | 1604-- FMT---42 | 1724-- FMT---42 |
| 1665-- 1 ---81 | 1605-- XFR---67 | 1725-- YTO---40 |
| 1666-- 9 ---11 | 1606-- 0 ---86 | 1726-- a ---13 |
| 1667-- XFR---67 | 1607-- 4 ---84 | 1727-- G ---15 |
| 1668-- DIV---35 | 1608-- 7 ---87 | 1728-- SPL---54 |
| 1669-- 1 ---81 | 1609-- KEY---30 | 1729-- FMT---42 |
| 1670-- 9 ---11 | 1610-- UP---27 | 1730-- PNT---45 |
| 1671-- XFR---67 | 1611-- 1 ---81 | 1731-- YTO---23 |
| 1672-- X ---36 | 1612-- . ---21 | 1732-- 1 ---81 |
| 1673-- 0 ---80 | 1613-- 5 ---85 | 1733-- 1 ---81 |
| 1674-- 2 ---82 | 1614-- X ---36 | 1734-- XFR---67 |
| 1675-- 1 ---81 | 1615-- DN---25 | 1735-- 4 ---84 |
| 1676-- FMT---42 | 1616-- X>Y---53 | 1736-- 5 ---85 |
| 1677-- FMT---42 | 1617-- 1 ---81 | 1737-- XFR---67 |
| 1678-- F ---16 | 1618-- 6 ---86 | 1738-- X ---36 |
| 1679-- 0 ---71 | 1619-- 5 ---85 | 1739-- 3 ---83 |
| 1680-- 0 ---13 | 1620-- 6 ---86 | 1740-- 0 ---86 |
| 1681-- CNT---47 | 1621-- FMT---42 | 1741-- XFR---67 |
| 1682-- G ---15 | 1622-- FMT---42 | 1742-- DIV---35 |
| 1683-- A ---62 | 1623-- YTO---40 | 1743-- 3 ---83 |
| 1684-- YTO---40 | 1624-- H ---74 | 1744-- 9 ---11 |
| 1685-- K ---55 | 1625-- CNT---47 | 1745-- XFR---67 |
| 1686-- E ---60 | 1626-- G ---15 | 1746-- DIV---35 |
| 1687-- YTO---23 | 1627-- YTO---23 | 1747-- 3 ---83 |
| 1688-- CNT---47 | 1628-- 0 ---13 | 1748-- 9 ---11 |
| 1689-- YTO---40 | 1629-- CNT---47 | 1749-- UP---27 |
| 1690-- E ---60 | 1630-- 1 ---81 | 1750-- XFR---67 |
| 1691-- A ---62 | 1631-- . ---21 | 1751-- 1 ---81 |
| 1692-- YTO---23 | 1632-- 5 ---85 | 1752-- 1 ---81 |
| 1693-- CNT---47 | 1633-- X<Y---52 | 1753-- UP---27 |
| 1694-- CLR---20 | 1634-- YTO---40 | 1754-- XFR---67 |
| 1695-- YTO---40 | 1635-- F ---16 | 1755-- 2 ---82 |
| 1696-- H ---74 | 1636-- 0 ---71 | 1756-- 9 ---11 |
| 1697-- G ---15 | 1637-- PSE---57 | 1757-- X ---36 |
| 1698-- SPL---54 | 1638-- CLR---20 | 1758-- DN---25 |
| 1699-- FMT---42 | 1639-- # ---56 | 1759-- - ---34 |
| 1700-- PNT---45 | 1640-- I ---65 | 1760-- KEY---30 |
| 1701-- YTO---23 | 1641-- C ---61 | 1761-- FMT---42 |
| 1702-- 1 ---81 | 1642-- K ---55 | 1762-- FMT---42 |
| 1703-- 0 ---80 | 1643-- CNT---47 | 1763-- YTO---40 |
| 1704-- XFR---67 | 1644-- H ---73 | 1764-- YTO---23 |
| 1705-- 4 ---84 | 1645-- E ---60 | 1765-- G ---15 |
| 1706-- 1 ---81 | 1646-- IND---31 | 1766-- SPL---54 |
| 1707-- XFR---67 | 1647-- CNT---47 | 1767-- FMT---42 |
| 1708-- X ---36 | 1648-- YTO---23 | 1768-- PNT---45 |
| 1709-- 4 ---84 | 1649-- H ---74 | 1769-- YTO---23 |

DESIGN OF
WELDING NECK
FLANGES

28

| | | |
|----------------------|----------------|----------------------|
| 1770-- 1 ---01 | 1828--XFR---67 | 1887--GTO---44 |
| 1771-- 2 ---02 | 1829-- 4 ---64 | 1888-- 1 ---01 |
| 1772--XFR---67 | 1830-- 5 ---85 | 1889-- 4 ---84 |
| 1773-- 1 ---01 | 1831-- X ---36 | 1890-- 7 ---07 |
| 1774-- 0 ---00 | 1832--KEY---38 | 1891-- 1 ---01 |
| 1775-- UP---27 | 1833--XTO---23 | 1892-- UP---27 |
| 1776--XFR---67 | 1834-- 4 ---04 | 1893--FMT---42 |
| 1777-- 1 ---01 | 1835-- 5 ---05 | 1894--FMT---42 |
| 1778-- 1 ---01 | 1836--S/R---77 | 1895--YTO---48 |
| 1779-- + ---33 | 1837--FMT---42 | 1896-- F ---16 |
| 1780-- . ---21 | 1838--FMT---42 | 1897-- R ---62 |
| 1781-- 5 ---05 | 1839-- G ---15 | 1898--SFL---54 |
| 1782-- X ---36 | 1840-- 1 ---01 | 1899--FMT---42 |
| 1783--XFR---67 | 1841--DIV---35 | 1900--STP---41 |
| 1784-- 1 ---01 | 1842-- G ---15 | 1901--PNT---45 |
| 1785-- 0 ---00 | 1843-- 0 ---71 | 1902--XY---53 |
| 1786-- UP---27 | 1844--SFL---54 | 1903-- 1 ---01 |
| 1787--XFR---67 | 1845--FMT---42 | 1904-- 9 ---11 |
| 1788-- 1 ---01 | 1846--GTO---44 | 1905-- 3 ---03 |
| 1789-- 2 ---02 | 1847-- 0 ---00 | 1906-- 0 ---00 |
| 1790-- + ---33 | 1848-- 0 ---10 | 1907--FMT---42 |
| 1791-- . ---21 | 1849-- 0 ---10 | 1908--FMT---42 |
| 1792-- 5 ---05 | 1850-- 0 ---10 | 1909--YTO---48 |
| 1793-- X ---36 | 1851--FMT---42 | 1910-- G ---15 |
| 1794-- IN---25 | 1852--FMT---42 | 1911-- C ---61 |
| 1795--X <y>---52</y> | 1853-- H ---74 | 1912--CNT---47 |
| 1796--KEY---38 | 1854--DIV---35 | 1913-- G ---15 |
| 1797--CNT---47 | 1855-- H ---74 | 1914--XTO---23 |
| 1798--CNT---47 | 1856-- 0 ---71 | 1915-- a ---13 |
| 1799--CNT---47 | 1857--SFL---54 | 1916--CNT---47 |
| 1800--FMT---42 | 1858--FMT---42 | 1917--YTO---48 |
| 1801--FMT---42 | 1859--GTO---44 | 1918-- F ---16 |
| 1802--YTO---48 | 1860-- 0 ---00 | 1919-- R ---62 |
| 1803-- C ---61 | 1861-- 9 ---11 | 1920--CLR---20 |
| 1804-- G ---15 | 1862-- 2 ---02 | 1921-- N ---73 |
| 1805--SFL---54 | 1863-- 6 ---06 | 1922-- E ---60 |
| 1806--FMT---42 | 1864--XFR---67 | 1923--IND---31 |
| 1807--PNT---45 | 1865-- X ---36 | 1924--CNT---47 |
| 1808--GTO---44 | 1866-- 3 ---03 | 1925--XTO---23 |
| 1809-- 1 ---01 | 1867--XFR---67 | 1926-- K ---55 |
| 1810-- 0 ---10 | 1868-- X ---36 | 1927--CLR---20 |
| 1811-- 9 ---11 | 1869-- 4 ---04 | 1928--CLR---20 |
| 1812-- 2 ---02 | 1870--XFR---67 | 1929--FMT---42 |
| 1813--LBL---51 | 1871-- X ---36 | 1930-- UP---27 |
| 1814-- J ---75 | 1872-- 1 ---01 | 1931--XFR---67 |
| 1815--DIV---35 | 1873--GTO---44 | 1932-- 1 ---01 |
| 1816--KEY---38 | 1874-- 0 ---00 | 1933-- 1 ---01 |
| 1817-- F ---76 | 1875-- 1 ---01 | 1934--X <y>---52</y> |
| 1818-- UP---27 | 1876-- 1 ---01 | 1935-- 1 ---01 |
| 1819-- UP---27 | 1877-- 9 ---11 | 1936-- 9 ---11 |
| 1820--XFR---67 | 1878--KEY---38 | 1937-- 6 ---06 |
| 1821-- 4 ---04 | 1879--FMT---42 | 1938-- 2 ---02 |
| 1822-- 4 ---04 | 1880--FMT---42 | 1939--FMT---42 |
| 1823-- X ---36 | 1881--YTO---48 | 1940--FMT---42 |
| 1824-- IN---25 | 1882-- C ---61 | 1941--YTO---48 |
| 1825--XTO---23 | 1883--SFL---54 | 1942-- a ---13 |
| 1826-- 4 ---04 | 1884--FMT---42 | 1943-- G ---15 |
| 1827-- 4 ---04 | 1885--PNT---45 | 1944--CNT---47 |
| | 1886-- UP---27 | 1945-- G ---15 |

DESIGN OF
WELDING NECK
FLANGES

| | |
|----------------|----------------|
| 1946--XTO---23 | 1994-- 5 ---05 |
| 1947-- o ---13 | 1995-- X ---36 |
| 1948--CNT---47 | 1996--XFR---67 |
| 1949--YTO---40 | 1997-- 1 ---01 |
| 1950-- F ---16 | 1998-- 0 ---00 |
| 1951-- A ---62 | 1999--X<Y---52 |
| 1952--CLR---20 | 2000-- 2 ---02 |
| 1953-- N ---73 | 2001-- 0 ---00 |
| 1954-- E ---60 | 2002-- 2 ---02 |
| 1955--IND---31 | 2003-- 9 ---11 |
| 1956--CNT---47 | 2004--FMT---42 |
| 1957--XTO---23 | 2005--FMT---42 |
| 1958-- K ---55 | 2006--YTO---40 |
| 1959--CLR---20 | 2007-- H ---74 |
| 1960--CLR---20 | 2008-- G ---15 |
| 1961--FMT---42 | 2009--CNT---47 |
| 1962--XFR---67 | 2010-- G ---15 |
| 1963-- 1 ---01 | 2011--XTO---23 |
| 1964-- 2 ---02 | 2012-- o ---13 |
| 1965--X<Y---52 | 2013--CNT---47 |
| 1966-- 1 ---01 | 2014-- 1 ---01 |
| 1967-- 9 ---11 | 2015-- . ---21 |
| 1968-- 9 ---11 | 2016-- 5 ---05 |
| 1969-- 2 ---02 | 2017--YTO---40 |
| 1970--FMT---42 | 2018-- F ---16 |
| 1971--FMT---42 | 2019-- A ---62 |
| 1972--YTO---40 | 2020--CLR---20 |
| 1973--XTO---23 | 2021-- N ---73 |
| 1974-- G ---15 | 2022-- E ---60 |
| 1975--CNT---47 | 2023--IND---31 |
| 1976-- G ---15 | 2024--CNT---47 |
| 1977--XTO---23 | 2025--XTO---23 |
| 1978-- o ---13 | 2026-- K ---55 |
| 1979--CNT---47 | 2027--CLR---20 |
| 1980--YTO---40 | 2028--FMT---42 |
| 1981-- F ---16 | 2029--GTO---44 |
| 1982-- A ---62 | 2030-- 1 ---01 |
| 1983--CLR---20 | 2031-- 0 ---00 |
| 1984-- N ---73 | 2032-- 8 ---10 |
| 1985-- E ---60 | 2033-- 2 ---02 |
| 1986--IND---31 | 2034--END---46 |
| 1987--CNT---47 | |
| 1988--XTO---23 | |
| 1989-- K ---55 | |
| 1990--CLR---20 | |
| 1991--FMT---42 | |
| 1992-- 1 ---01 | |
| 1993-- . ---21 | |

CONCLUDING REMARKS

This computer aided design program presents an "interactive" procedure for the engineer utilizing the electronic desk top calculator to obtain the optimum circular, integral or optional type flanges under internal pressure. The design criteria meets the requirements of the 1971 ASME Pressure Vessel Code. This program provides the flexibility of comparing the computed stresses for a selected flange thickness to the allowed code value for a given geometry. Since the design equations for loose, non-circular and split flanges subject to internal and external pressure are similar to the integral and optional type flange, this program could easily be modified and adapted to those types of design. The other types of flanges in conjunction with different gasket and outer rim contacts are not as easily programmed but the general outline and procedure is valid.

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